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AQUATIC RESOURCES NEWS
A REGULATORY NEWSLETTER
Headquarters, U.S. Army Corps of Engineers, Regulatory Branch

A Note from Headquarters

Compensatory mitigation has long been associated with impacts to wetlands however, as stated in RGL 02-02 and the 2002 NWPs, all impacts to waters of the U.S. should be mitigated. The only exception to this would be where the District Engineer has determined, on a case-by-case basis, that mitigation for specific project impacts is impracticable based on the availability of suitable locations, constructibility, overall costs, technical requirements, and logistics. There may be instances where permit decisions do not meet the "no overall net loss of wetlands" goal because compensatory mitigation would be impracticable, or would only achieve inconsequential reductions in impacts. Consequently, the "no overall net loss of wetlands goal" may not be achieved for each and every permit action although all Districts will strive to achieve this goal on a cumulative basis, and the Corps will achieve the goal programmatically.

The requirement to mitigate impacts to wetlands and waters includes those functions associated with lakes and rivers as well as ephemeral, intermittent and perennial streams, all of which are regulated by the Corps. The RGL states that districts may give compensatory mitigation credit for inclusion of upland and riparian areas adjacent to other waters when they are an enhancement of the aquatic environment on a watershed basis. In order to determine whether lost functions may be replaced by a compensatory mitigation plan and the amount of mitigation that can be credited, some type of functional assessment must be done. Mitigation projects for streams should generally replace linear feet of stream on a one-for-one basis where functional assessment is not practical. However, a number of Corps districts have developed or have started to develop stream functional assessment procedures to answer the question of whether or not lost aquatic resource functions are being replaced. This is the first of three issues of the ARN to deal with functional assessment and mitigation of streams and riparian areas.

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Regulatory Developments: A Note from the Editor

This issue focuses on examples of field efforts to develop stream impact assessment procedures. Stream impacts are receiving increasing attention by the public as well as government agencies. Indeed, the Federal Interagency Mitigation Action Plan identifies improvement of stream impact assessment as an important element and task (see Current Events

Distribution of Aquatic Resources News

The *Aquatic Resources News* will be distributed to field staff by email. The Newsletter will also be available on the IWR website within the month at:
http://www.iwr.usace.army.mil/iwr/regulatory/regulintro.htm
Or you may contact the Editor, Bob Brumbaugh, CEIWR-PD (703) 428-7069 Robert.w.brumbaugh@usace.army.mil. HQ point-of-contact for the newsletter is Katherine Trott, CECW-OR (202) 761-4617 Katherine.l.trott@usace.army.mil

page 10). The recently released Compensatory Mitigation Regulatory Guidance Letter (RGL 02-02) discusses the requirement of compensatory mitigation for stream impacts and calls for careful consideration of alternative approaches to stream functional assessment in order to improve upon stream compensatory mitigation performance.

This newsletter presents three efforts, starting with a relatively complex interagency initiative developed in Eastern Kentucky. A second initiative is in Virginia where the Norfolk District is working with the state to develop an impact assessment model for piedmont streams. The Norfolk District model is a rapid assessment tool that bridges the gap between a full functional assessment model and a subjective assessment procedure currently in place. These articles summarize district approaches for using assessment protocols tailored to the needs of the regulatory program for evaluating streams impacts and compensatory mitigation requirements in their regions. A third article examines the Honolulu District's attempt to apply the Instream Flow Incremental Methodology to negotiate conservation flows in the evaluation of a permit application for a proposed water diversion and hydropower plant on a Hawaiian stream. The District's experience points to the need to evaluate model applicability before employing that model. The examples in this newsletter also highlight development of models that use existing data.

Some readers will note that the examples discussed in this newsletter were all set in humid environments, and two of the three in the eastern United States. Some stream functions identified by the models discussed may differ in nature and importance for ephemeral streams in the western United States, especially in semi-arid regions.

Stream Assessment Protocol for Headwater Streams in the Eastern Kentucky Coalfield Region

Jerry Sparks, James Townsend, Todd Hagman and Darvin Messer

Over the past several years, the scientific community, government agencies, and the general public have become increasingly aware of the role headwater streams play in maintaining environmental quality. This awareness has lead to expanded efforts in the stewardship and management of headwater resources and increased research into critical headwater stream processes. The Clean Water Act (33 U.S.C. 1344) plays a significant role in regulating impacts to headwater streams at the national scale. Section 404 of the Act directs the U.S. Army Corps of Engineers (Corps), in cooperation with the U.S. Environmental Protection Agency (EPA), to administer the 404 Regulatory Program (404) for permitting the discharge of dredged or fill material in "waters of the United States" which, by definition, include headwater streams that are part of a tributary system encompassing navigable waters. This has become a very contentious issue in the coal mining region of the Appalachian Mountains.

An interagency team, including members from the Corps, the EPA, the U.S. Fish and Wildlife Service (USFWS), the Kentucky Division of Water (KDOW), and the Kentucky Department of Fish and Wildlife Resources (KDFWR) was assembled to address the needs for a headwater stream assessment procedure that would accommodate the Section 404 programmatic requirements in the eastern Kentucky Coalfield Region. The team considered a variety of methods that have been developed to assess stream quality. However, none have received wide spread use or acceptance in the Section 404 program because they were unable to satisfy all of the technical or programmatic requirements. The most important requirement has been the need to assess stream functions accurately and efficiently within the limited time and resource constraints inherent in the regulatory program. EPA's Rapid Bioassessment Protocol (RBP) (Barbour *et al.*, 1999)[1] was the assessment procedure singled out by the interagency team as having the greatest potential utility for the regulatory program's needs. This protocol has undergone extensive peer review and is based on sound ecological principles. Variations of this protocol can be rapid, thereby accommodating the concerns about time and resource constraints within the Section 404 program. This article summarizes an approach for using the RBP in a manner that assesses overall stream ecosystem integrity and also satisfies the technical and programmatic requirements of the Section 404 program for headwater streams in the Eastern Kentucky Coalfield Region.

The headwater stream ecosystem may be envisioned as being composed of two very broad subsystems or components: 1) the abiotic component and 2) the biotic component. These two components are interdependent operating on multiple scales (i.e., regional, landscape, stream corridor, stream reach, etc.) and interact to perform a number of ecological processes or functions within the landscape. These, often ephemeral or intermittent, streams are the key interface between the surrounding landscape and larger waterbodies downstream. Healthy headwater streams have a productive ecosystem, and include habitat that contains relatively distinct and diverse assemblages of invertebrates. This biotic component, by assimilating nutrients, organic matter, and sediments, ensures high quality water flows downstream. This high quality water provides goods and services (e.g., water supply, recreation, waste assimilation, flood control, and ecological values) important to the public interest. To assess the integrity of the headwater stream ecosystem and, therefore its capacity to provide goods and services, both the abiotic and biotic

[1] Barbour, M.T., J. Gerritsen, B.D. Snyder, J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish, second edition. EPA 841-B-99-002. US EPA, Washington, DC.

components of the system must be considered. Thus, following this generalized line of logic the following conceptual model may be constructed:

Ecological Integrity = Biotic Integrity + Abiotic Integrity

Biotic Integrity

Thirty-one (31) macroinvertebrate biological attributes (biometrics) were calculated and evaluated for discrimination efficiency, sensitivity, redundancy, and variability. Effort was given to include metrics covering a wide scope of ecological attributes (e.g., structure, tolerance, habit, and function). Five metrics (**taxa richness, EPT richness, mHBI, %Ephemeroptera, and %Chironomidae+Oligochaeta**) were selected for use in a Macroinvertebrate Bioassessment Index (MBI). Data analysis also revealed that the output of the MBI model using family level taxonomy and sampling only the riffle habitats was highly correlated with the output derived from using genus and species level taxonomy and sampling multiple habitats. The use of family level taxonomy and the sampling of a single habitat would reduce the time and effort required to glean useful data in certain situations (e.g., pre-application consultations and project/mitigation site screening) and also improve the quality of the information submitted by a permit applicant by eliminating less relevant data. The approach recommended by the interagency team incorporates the MBI model to serve as the indicator for the integrity of the biotic component for the overall headwater stream ecosystem relative to the reference stream.

Abiotic Integrity

The assessment protocol was validated in selected sites with catchment areas ranging from 50 to 2000 acres. Reference and test stream data sets did not differ significantly in mean catchment area, riffle substrate size, stream width, elevation, slope, and distance-to-source (Mann-Whitney, $p>0.1$). In contrast, the two data sets differed significantly in mean riffle embeddedness, riparian width, canopy score, conductivity, and temperature ($p<0.01$). Both stepwise discriminant function analysis (DFA) and principal components analysis (PCA) showed that **conductivity**, **riparian width**, **canopy**, and **embeddedness** best separated reference (least disturbed) and test (degraded) sites. In addition, cluster analyses and box and whisker plots also indicated that EPA **RBP habitat scores** successfully distinguished reference from test sites. These physical habitat parameters which proved to provide the best discriminatory power between least disturbed streams and those that were degraded serve as the variables used to assess for the abiotic integrity of the stream ecosystem.

Macroinvertebrates and physical habitat data were sampled in the spring index period (mid-February to late-May) from 58 sites. These data and subsequent analyses were used as a basis to compose and calibrate recommended headwater stream assessment model(s) applicable to the Eastern Kentucky Coalfield Region (See Figure 1 for map of region). The most robust form of these models includes variables representing both the biotic component and the abiotic component shown to be statistically significant for these headwater stream ecosystems and will, therefore, collectively provide an index of ecological integrity.

Eq. 1: Ecological Integrity Index = Macroinvertebrate Bioassessment Index + Conductivity + Total Habitat Score / 3

In exceptional circumstances, such as an absence of comparable biotic data or when there is a lack of time, a less robust form of the model that includes only significant abiotic habitat parameters could be used. Confidence in less robust forms of the model is supported by an analysis of the above referenced data, which revealed a moderately strong correlation between the integrity of the biotic communities and the habitat variables chosen to represent the abiotic component of the stream ecosystem.

Eq. 2: Ecological Integrity Index = Conductivity + Total Habitat Score / 2

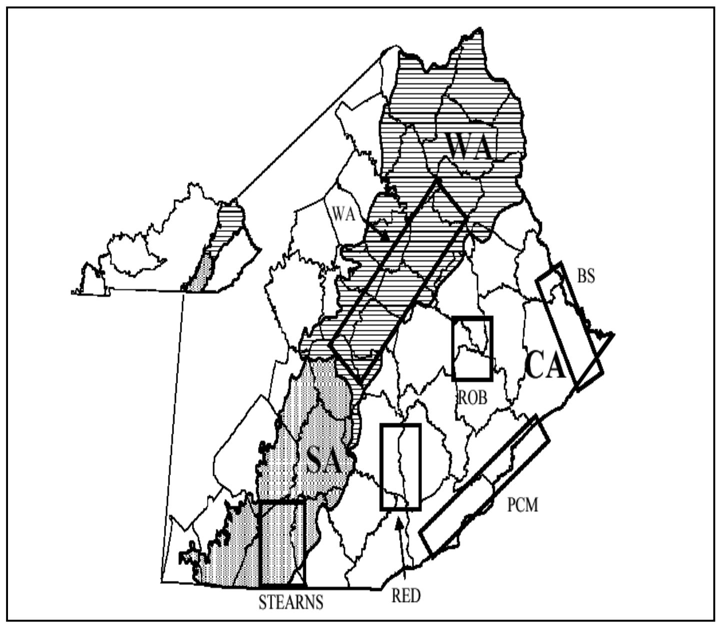

Figure 1: Generalized map of six sampling areas within the Eastern Kentucky Coalfield Region. CA = Central Appalachian Ecoregion, SA = Southern Appalachian Ecoregion, Western Allegheny Ecoregion

The variables of riparian width, canopy, and embeddedness are inherent within the assessment of habitat and the calculation of the Total Habitat Score. However, if time and data are in very short supply (e.g., preapplication meetings or site screening) then one may gain some insight from a cursory evaluation of that subset of significant variables.

All of these models serve to provide an estimate of the ecological integrity of a headwater stream's ecosystem, relative to the reference (i.e., least disturbed) stream conditions in the same region 9 (See Figure 2 for illustration of model). The output of the models range from 0 – 1, and is calibrated such that a score of 1.0 is given for stream conditions indicative of least disturbed or reference streams in the region. The models were developed with the regulatory program limitations in mind, as well as the data requirements that may be incurred by applicants seeking a Section 404 permit. An effort was made to minimize the burden on the regulated public while at the same time ensuring that meaningful data were obtained. This allows for good decision making, effective administration of the Section 404 permitting program, and fair, reasonable, and timely responses to the regulated public, while also adequately protecting the aquatic environment.

Assessment Protocol

The recommended assessment procedure consists of characterization, assessment, and analysis components. The characterization component is largely embodied by the current requirements of the EPA's RBP and involves using a checklist and describing the physical characteristics of the headwater stream ecosystem and the surrounding landscape. The characterization component is specific to the Section 404 program and includes potential consequences of the proposed project on the aquatic environment. The assessment component involves the application of the developed models and the calculation of ecological integrity indices for a defined headwater stream ecosystem under existing (i.e., preproject) conditions, and if appropriate, predicted (postproject) conditions. The analysis component involves the application of the assessment results to the following: 1) description of the potential impacts of a proposed project, 2) description of the actual impacts of a completed project, 3) identification of ways to avoid and minimize impacts of a proposed project, 4) determination of the least damaging alternative for a proposed project, 5) determination of compensatory mitigation needs for a proposed project, 6) determination of restoration potential for headwater streams, 7) development of design criteria for stream restoration projects, 8) planning, monitoring and managing stream mitigation or restoration projects, 9) evaluation of performance standards or success criteria for headwater stream mitigation efforts, 10) comparison of stream management alternatives or results, 11) determination of appropriate in-lieu-fee ratios, and 12) identifying priorities for in-lieu-fee mitigation projects. Readers will learn more regarding the use of this approach for mitigation purposes, including in lieu fees, in an upcoming newsletter article.

The strength of the recommended approach is that it promotes an ecosystem approach based on accepted methodologies and real data calibrated to the existing spectrum of conditions found within a specific region. In addition, it takes advantage of information and data that is currently being supplied by applicants to the regulatory program and therefore imparts little additional burden to the

EII Calculation for High Gradient Streams in Eastern Kentucky Coalfield (VERSION 2002.6)
(Genus/species Level Taxonomy - Riffle Only Sample)

Project ID:	Division Meeting - Robinson Forest Field Visit
Stream/Reach:	John Carpenter Fork (least disturbed stream condition)
Assessment Objectives:	Estimate quality/integrity of stream ecosystem using Genus Level Taxonomy and Sampling Riffles Only

0.98	Ecological Integrity Index (MBI + Habitat Integrity + Conductivity)
1.00	Ecological Integrity Index (Habitat Integrity + Conductivity)

>>>>>>> *Enter quantitative or categorical measure from Field Data Sheet in shaded cells*

Variables	Measure	Units	Subindex
RBP Habitat Parameters			
1. Epifaunal Substrate	19	no units (0-20)	
2. Embeddedness	17	no units (0-20)	
3. Velocity/Depth Regime	18	no units (0-20)	
4. Sediment Deposition	15	no units (0-20)	
5. Channel Flow Status	15	no units (0-20)	
6. Channel Alteration	18	no units (0-20)	
7. Freq. Of Riffles (bends)	19	no units (0-20)	
8. Bank stability (both combined)	16	no units (0-20)	
9. Veg. Protection (both combined)	17	no units (0-20)	
10. Riparian Width (both combined)	20	no units (0-20)	
Total Habitat Score	174	no units	
Habitat Integrity			1.00
Macroinvertebrate Data - *Genus/species Level*			
11. Genus/species Taxa Richness	29	# of taxa sampled	
12. Genus/species EPT Richness	15	# of EPT species sampled	
13. % Ephemeroptera	42.98	% Mayflies (0-100)	
14. % Chironomidae & Oligochaeta	0.88	% Midges & Worms (0-100)	
15. % Clingers	61.99	% Clingers (0-100)	
16. mHBI	2.92	no units	
Macroinvertebrate Bioassessment	73.71	no units	0.95
Conductivity	38.8	microMHOs	1.00

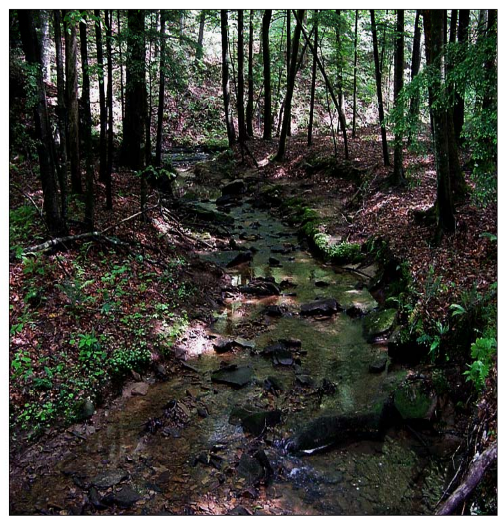

Figure 2. Assessment Model. For more information see the website identified at the end of this article.

regulated public. The limitations of the assessment procedure should also be identified at the outset. In order for the MBI scores to be effective, adherence to sampling procedures and sample index period is important. Recommended time frames for sampling headwater streams ranges from mid-February to late-May. Samples collected before or after these dates may give inaccurate results and caution should be used when interpreting benthic data gathered outside the sampling index period. In addition, the tool may only be applied to headwater streams in the region from which the reference data was collected. The models and variables are calibrated at the stream reach scale and thus provide little insight into variables and processes that are performed at other scales. Sound geomorphologic principles should also be considered, along with ecological assessment models, when assessing stable stream morphology. A potential limitation to this approach is that the ecological integrity indices do not assign value (i.e., relative importance based on human perception) to stream ecosystems. It is also important to note that while developing these models the interagency team restrained our effort to that of using data that were already being provided by applicants seeking permits. Applications for Section 404 permits routinely contained macroinvertebrate surveys, RBP Habitat assessments and scores, and water chemistry data. Our effort focused on constructing models that would allow us to take this existing data and make better permit decisions based on meaningful interpretations. It is appreciated that a more thorough treatment of modeling stream functions may be accomplished with a more intensive effort. However, this would also take a greater expenditure of resources and may also impose new requirements on the information submitted by applicants. Our goal was to simply take existing data and construct from this a meaningful interpretation that would lead to better permit decisions. The ecological integrity indices derived from the models may serve as a type of environmental "currency" and can be used to estimate a stream's functional capacity or relative quality. They may also predict the amount of loss or gain of stream function(s). However, they cannot be used to assign the value (i.e., relative importance of benefits, goods, and services resulting from a proposed project. This requires other methods designed specifically for the purpose of assigning value, and is beyond the scope or intent of the stream assessment protocol.

For more details on this subject, please contact Jerry Sparks 606) 642-3053. For more information of this assessment protocol, please visit:
http://155.80.93.250/orf/info/EKYStreamAssess/eastkystreamassessment.htm

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STREAM ASSESSMENT IN VIRGINIA - AN EVOLVING AND DYNAMIC PROCESS

Michael A. Schwinn and Gregory D. Culpepper

Ribbons of water snake across the earth's crust and carve tortuous paths out of dirt and rock. From the raging currents of the Colorado deep within the bowels of the Grand Canyon to the serene elegance of the James, few natural processes can so alter the landscape in such subtle and dynamic ways as a river. In Virginia there are approximately 248,000 miles of streams and rivers. They range in size from small headwater streams one can step across to those large enough to float a battleship. And most are regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act or Sections 10 & 13 of the Rivers and Harbors Act.

Stream impact assessment and mitigation are relatively new frontiers in the eastern United States. Not until publication of the Corps' Nationwide Permits in 1996 were specific provisions made to address stream impacts. In 1996, only Nationwide Permit No. 26 (now expired) contained restrictions on stream impacts, and those restrictions only applied to impacts in excess of 500 linear feet. Re-issuance of the Nationwide Permits in 2002 lowered the threshold to 300 linear feet, distinguished between intermittent and perennial streams and allowed riparian buffers as compensatory mitigation. The number of nationwide permits with restrictions on stream impacts expanded from one in 1996 to six in 2002. The ecological importance of streams, coupled with increasing stream impacts and losses nationwide, created the impetus to regulate streams more stringently. In addition to the national impetus, the Norfolk District similarly saw the need for a more aggressive approach to stream regulation in the Commonwealth of Virginia. While the Norfolk District has an extensive track record regulating and mitigating wetland impacts, specific guidance addressing stream impacts and mitigation was lacking. The Norfolk District organized an internal technical team in 2000 to address the issue. The technical team presented draft guidance evaluating stream impacts and mitigation and it was subsequently adopted by the Norfolk District in 2001.

The genesis of stream assessment by the Norfolk District began with the 2001 draft guidance. In determining what level of mitigation should be required, the Norfolk District needed some basis for establishing the condition and quality of the affected stream. Early assessment iterations, as per the 2001 draft guidance, entailed qualitative descriptions of a stream's condition and focused on such characteristics as base flow, pools and riffles, aquatic fauna, water quality, riparian condition, wildlife corridors and the presence of adjacent wetlands. A later version introduced some quantification by including a numeric ranking system. It was based on those same characteristics, but these were now scaled from 1 (low) to 3 (high). The biggest drawback was that it still relied on a qualitative evaluation of the stream's condition without the benefit of objective reference points or standardized measures for determining what's beneficial and what's detrimental. The methodologies therefore left considerable room for each individual investigator's particular biases to enter into the evaluation.

The 2001 draft guidance also included provisions to accept in-lieu fees (ILF) for mitigation when other forms of mitigation were deemed impracticable. ILF fees for stream impacts were tied to an impacted stream's overall condition and level of mitigation necessary to compensate for impacts. It was necessary to distinguish between streams in good condition and those in poor condition in order to set ILF mitigation costs. The ILF cost structure was determined by, costs of land acquisition, construction and management, costs for restoration, planting, legal fees, survey costs, monitoring, overhead, and other appropriate costs. The ILF gave needed flexibility to the mitigation process, particularly since stream mitigation was a new concept and mitigation opportunities were limited.

Stream impact evaluation and mitigation, could be variable because of the subjective interpretation of the various stream characteristics contained in the 2001 draft guidance. With different investigators involved, consistency and repeatability of the approach was also a concern. In addition, the Norfolk District and the Virginia Department of Environmental Quality committed to jointly develop a more quantitative stream assessment tool that both agencies would use as part of a State Programmatic General Permit (SPGP) developed in 2002. The SPGP delegated certain Section 404 regulatory responsibilities to the Commonwealth of Virginia and included stream impact assessment and compensatory mitigation requirements.

Because development of a fully functional stream assessment model could take several months, there was a need for a more rapid assessment tool for the regulatory program that was still objective and quantitative. Therefore, the Norfolk District and the Virginia DEQ decided to pursue an interim stream assessment protocol that could bridge the gap between the subjective measures currently in place and a full functional assessment model. The interim stream assessment approach is not a full functional assessment model in the sense that the Corps' Hydro-Geomorphic (HGM) assessment or the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP) are. Rather, it is an abbreviated assessment tool that utilizes similar principles of full functional assessment models. The interim stream assessment approach makes use of regionally specific reference stream reaches, ranging in condition from least disturbed to most disturbed. Least disturbed streams are presumed to function at a higher capacity relative to moderately disturbed and most disturbed streams. Least disturbed streams serve as reference standards from which a suite of selected variables reflecting overall stream condition are calibrated.

Based on a review of the literature, six variables, whose relationship to overall stream health could be established, were selected as indicators of stream condition: riparian corridor width, amount of development in the receiving stream's watershed, the degree to which the channel has downcut or is incised in its floodplain, the degree and severity of bank erosion, whether or not the stream has been channelized and to what degree, and the amount and condition of instream habitat. These six variables are used as yardsticks that gauge the disturbance level of a particular stream relative to other, similar streams. The underlying premise is that least disturbed streams have higher functional capacities or exhibit greater ecological integrity relative to those with greater levels of disturbance. Therefore, while specific stream ecological functions have not been identified, it is presumed that the highest sustainable ecological functions occur in the least disturbed streams relative to moderately disturbed and most disturbed stream systems.

The interim assessment approach is a relative measure of disturbance that compares similar stream types within the same physiographic region. Regionally specific streams are used because of their geomorphic and ecologic similarity and, ultimately, functional similarity. Streams in one physiographic region are not compared to streams in any other region. For example, stream habitat in the Piedmont Physiographic Region is markedly different from stream habitat in the Blue Ridge Physiographic Region and the two cannot be compared with any degree of confidence or meaning. It is only appropriate to compare stream habitat relative to similar streams within the same physiographic region. This allows one to sort out causal differences of climate, geology and topography from those of strictly anthropogenic origin.

The Piedmont Physiographic Region was selected as a priority region because of the intense development pressures it has experienced since European settlement. The Piedmont Physiographic Region is a geographic area roughly 16,700 square miles in size that is bordered on the west by the Blue Ridge and on the east by the Coastal Plain. It includes some of Virginia's fastest growing population centers along the I-95 corridor from Richmond to Washington D.C.

A subset of streams in the Piedmont Physiographic Region ranging from least disturbed to most disturbed was selected in order to capture the amount of variation for each variable measured in each disturbance category. The least disturbed streams served as reference standard reaches and were used to calibrate the acceptable range of disturbance for least disturbed versus moderately disturbed and most disturbed streams. By definition, each selected variable for least disturbed streams is assigned a condition index of 1.0. Variable metrics for moderately disturbed and most disturbed stream conditions are qualitatively scaled against reference standard reaches and assigned condition indices of 0.5 and 0.25, respectively. For example, field conditions of least disturbed streams showed less than 15 percent total bank erosion throughout the total channel length examined. By definition then, streams exhibiting less than 15 percent channel erosion are given a condition index of 1.0 for that particular variable. Streams with greater than 15 percent erosion but less than 30 percent erosion fell within the moderately disturbed category and was given a condition index of 0.5. Those with greater than 30 percent total bank erosion were in the most disturbed class and given a condition index of 0.25.

The Condition Index for the Bank Erosion variable based on field measurements in the Piedmont region was determined as follows:

Bank Erosion Index =

1.0 = <15% stream bank eroding
0.5 = 15%-30% stream bank eroding
0.25 = >30% stream bank eroding

Where percent stream bank erosion is calculated as:

$$\frac{\text{[length of eroding right bank + length of eroding left bank]}}{\text{[stream assessment reach (ft) X 2]}}$$

The indices are used to calculate an overall Stream Condition Unit by multiplying the length of stream under consideration (stream assessment reach) by the condition index of each particular variable such that:

Stream Condition Unit = Condition Index X Stream Assessment Reach

In this way, overall stream condition can be quantifiably linked to impacts and mitigation requirements. For example, impacts to 300 linear feet of channel having a bank erosion condition index of 1.0 (<15% total bank erosion) would be expected to cause the loss of 300 Stream Condition Units (1.0 X 300); whereas impacts to 300 feet of stream channel having a bank erosion condition index of 0.5 (total bank erosion of between 15% and 30%) would result in the loss of only 150 Stream Condition Units (0.5 X 300).

The six variables also provide the basis for mitigation goals and objectives since factors affecting a stream's condition can be identified, quantified and manipulated. In the previous example, mitigation could focus on stream bank improvements that would raise the condition index from, say 0.5 to 1.0 a condition index increase of 0.5. The objective in this case would be to affect enough stream bank improvements to reduce overall bank erosion to less than 15 percent throughout the mitigation stream assessment reach.

Similar to impacts, mitigation is also tied to stream length in determining mitigation Stream Condition Units. In this example, reducing bank erosion to less than 15 percent throughout 300 linear feet of channel results in a net gain of 150 Stream Condition Units (0.5 X 300). This would fully compensate the impacted stream having a bank erosion condition index of 0.5 but would under-compensate the stream with a bank erosion condition index of 1.0. To fully compensate the latter, an additional 300 feet of channel also having a bank erosion condition index of 0.5 would have to be added onto the mitigation for a total mitigation stream length of 600 linear feet (0.5 X 600 = 300 Stream Condition Units).

Since summer of 2002, the Norfolk District and the Virginia DEQ have been involved in selecting reference stream reaches, collecting data, calibrating variables and field-testing the interim stream assessment approach. Although this is a highly simplistic measure of geomorphically and ecologically complex systems, it is a substantial improvement over past rapid stream assessment endeavors. The primary merit of this approach lies in its reliance on regionally specific reference stream reaches that exist in time and space, and upon measurable attributes related to stream health. The methodology is repeatable; the results reproducible, and that promotes consistency in stream assessment regardless of the investigator. It also provides the framework for continued data collection, analyses and eventual model development.

For more details on this article, contact Mike Schwinn (757) 441-7182

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An Assessment of the US Fish and Wildlife Service Instream Flow Incremental Methodology Application in Hawaii

Michael T. Lee

In 1990, the Honolulu District accepted a permit application to construct water diversions and a hydropower plant on the Wailuku-Honolii Streams, Hilo, Hawaii Island. During the public interest review, the US Fish and Wildlife Service (USFWS) expressed concern that reduced stream flow would impact two native goby fish species and suggested using the USFWS Instream Flow Incremental Methodology (IFIM) to negotiate conservation flows in order to protect the gobies.

The Honolulu District evaluated the applicability of IFIM to torrential Hawaiian Streams with assistance of an operations analyst from the Honolulu District Information

Management Office and scientists from the Engineering Research and Development Center (ERDC). This article describes IFIM procedures, the factors and variables measured in IFIM and concludes with a discussion on the applicability of IFIM to Hawaiian stream ecology.

Description of the IFIM assessment protocol

IFIM is a stream habitat preference modeling protocol. The protocol merges traditional stream hydrology and hydraulic modeling techniques with a habitat evaluation procedure, i.e., an aquatic habitat evaluation procedure. The protocol assumes that fish will move their position in the stream, seeking their preferred velocity envelope, as stream flow velocity changes. The fish's movement to that preferred velocity envelope in the stream represents the fish's preferred velocity habitat. IFIM assumes that managing habitat protects the population and presumes that habitat availability reflects the fish population in a stream i.e. more habitat equals more fish.

The use of traditional hydraulic modeling techniques to forecast flow velocity and established habitat evaluation procedures provides a level of confidence in the protocol, as well as providing a structured forum for water engineers to discuss biological mitigation with biologists. Habitat units (cells with the preferred velocity) are calculated using the fish velocity preference curve in the IFIM model. The IFIM output is a habitat unit versus flow curve. The curve reflects the amount of habitat available for various flow regimes in the stream. Negotiators use the curve to agree on the amount of habitat to provide in the stream, thereby agreeing upon the necessary conservation flow. The curve also serves as a useful negotiating tool by illustrating habitat unit, i.e., flow, and differences between competing negotiators. The underlying presumption is that the amount of habitat provided will support an unspecified population of fish. In some cases, where a population is not present, the presumption is that the fish will populate the stream if habitat is provided.

Consensus is intrinsic to the IFIM process. Consensus insures that all participants who are interested in the flow negotiations and use IFIM, or any other another stream assessment protocol, will agree to alterations or methodologies used in IFIM. It is believed that if they have a consensus throughout the process that they will all agree to use the IFIM results. Consensus is as much part of the IFIM process, as the IFIM model protocol. IFIM would have achieved its purpose by simply having the participants agree on any stream assessment protocol for negotiating conservation flows, even if the IFIM protocol was not selected for use.

The consensus process also provides participants with an opportunity to teach each other and learn about the IFIM process. Ideally, the participants should have a working knowledge of stream hydrology and hydraulic modeling, an understanding of the fish species hydraulic ecology requirements and a working understanding of IFIM. Most often water developer consultants perform the IFIM work and guide the participants through the consensus process.

Factors or variables measured for the assessment

IFIM modeling generally follow these steps: 1) selecting a representative stream; 2) setting stream cell transects; 3) collecting hydrologic and hydraulic data; 4) developing a species flow velocity preference curve; 5) calibrating and running the IFIM model; and 6) using the results to negotiate conservation flow.

A study stream is divided into a number of stream segments. A representative stream study reach is selected. Transects across the represented study reach are established to describe the hydraulic elements within the study reach. The transects are surveyed with surveyor instruments to control points, which allow accurate measurement of water surface elevations. Sample points are set along each transect line. At each sample point, water surface elevations and flow velocities are measured. The flow velocities are measured at the top, middle and bottom of the water column at each sample point. Hydraulic data are collected over a sufficient number of flow events to calibrate the hydraulic model. The hydraulic models are then used to forecast velocities over a range of flow events.

A target species "velocity preference" curve, i.e., "habitat preference" curve, is developed by locating fish in the stream either within the representative reach or in the entire study reach. If actually measuring the fish "nose" velocity, measurements are taken wherever the fish are found. In lieu of field measurements, participants could agree to use species velocity preference curves from previous studies or to construct the velocity preference curve based on best professional judgment. The IFIM protocol contains models that combine the "habitat preference" curve with the hydraulic data producing the habitat units. IFIM then converts the habitat units from the representative stream reach to habitat units for the entire study reach.

The IFIM requires a high level of training and experience in hydrology and hydraulics and hydraulic ecology of the target species. The consensus process requires numerous meetings to agree on every facet and step of the protocol decisions, i.e., scoping, the representative reach, transect locations and stations, and to reach consensus at every decision point in the protocol. IFIM also anticipates educating and training participants in stream hydrology and hydraulics, and hydraulic ecology, so participants can understand and participate intelligently in the IFIM protocol. Field data collecting requires a level of precision and accuracy using surveying equipment to establish the control points and transects, as well as measuring water surface elevations and water velocities at various flows. However, this sense of precision and accuracy for measuring flow velocity is offset by biological variability, which cannot be measured accurately. A flow meter having a diameter of 2-inches may not actually measure velocities sensed by the fish at a 3mm resolution. The assumption that fish habitat can be defined as only a velocity component in the IFIM protocol is an over simplification of the complex, and sometimes poorly understood, hydraulic ecology requirements of a biological organism.

Hawaiian Stream Ecosystems

Hawaiian streams are typically high gradient, torrential, basaltic boulder strewn watercourses. In the Wailuku-Honolii Stream, the stream morphology is a series of cascading waterfalls and pools. The torrential flow characteristics reflect a highly variable, seasonal rainfall pattern and intensity. An example of the torrential flow pattern is rise and fall from five cfs (cubic feet per second) to 20,000 cfs and back to five cfs in a matter of hours (six to eight hours). While high rainfall events normally occur in the winter months of October to February, a high rainfall or storm event is just as likely to occur in the summer months from June to September, which is normally a dry period.

The native gobies are diadromous species, which evolved from marine species. The vertical distribution of the species (as high as 2000-foot elevation) is dependent upon their climbing ability. The adults spend their lives in the stream releasing eggs and larvae, which are carried to the ocean. In the ocean, the eggs or larvae develop into juvenile forms. Juvenile recruitment is believed to be triggered by a torrential flow event, i.e., a freshet. The juveniles move upstream (climbing up waterfalls) during the freshet and establish their adult ranges at various elevations in the stream. Not much is known about their adult stage movement in the stream. Population census techniques, to date, have not produced repeatable results, so the population size is difficult to estimate accurately.

The gobies are well-adapted for survival in the torrential streams. The gobies are essentially bottom dwellers with a modified pectoral fin, which acts as a "suction disc." Investigations using a microflow meter (3mm thermistor) indicated that the gobies live in the low flow and velocity shelters created by boulders and rocky substrate. They probably survive the torrential flows by hiding in these shelters using their adaptive abilities to "hang on" in the shelters. The microflow investigations suggest that the velocity shelters increase as the stream flow increases, representing an increase in habitat in IFIM terms. In IFIM terms gobies prefer zero velocity. However, gobies use the stream flow in ways not considered by IFIM. While hiding in velocity shelters (zero or low velocities) they dart into the high velocity flows to capture food drift. They also sense freshets or seasonal periods of high rainfall and use the high velocities to carry their eggs and larvae to the ocean, as well as to trigger recruitment.

The ease of use/expected results and applicability to Hawaiian streams

While the consensus process is intended to "level the playing field" allowing participants to learn from each other while applying IFIM or other modeling protocol, IFIM is not easy to use. This is especially true for individuals, who are not familiar with either stream hydrology and hydraulic modeling or the target species hydraulic ecology. A reasonable understanding of hydraulic modeling techniques is needed to understand the nuances of IFIM. Tweaking IFIM to express some nuance or to accommodate one participant's concern could have unforeseeable or unpredictable results that would not even be considered by the uninitiated or unwary. Technically suave IFIM practitioners may have an unfair advantage over the technically handicapped in the negotiations.

Learning and applying IFIM requires a lot of time, effort and expertise. The USFWS Hawaii office staff attempted to teach the group how to perform and use an IFIM assessment. The Honolulu District realized that it could not make an independent, informed decision about the methodology, and sent a biologist to attend all four USFWS IFIM classes at Fort Collins, Colorado. The courses spanned a two-year period. In order to better understand and evaluate IFIM output inferences, a statistician, who was skilled in operations and systems analysis, was recruited from within the Honolulu District Information Management Office. He assisted the biologist in analyzing and understanding the IFIM models and interpreting its outputs in relation to goby hydraulic ecology. ERDC was also contracted to employ thermister flow meter technology and hydraulic ecology expertise to aid in the evaluation. The effort was undertaken to understand how well the model assumptions and outputs reflected Hawaiian stream hydraulic ecology.

IFIM was developed for use in negotiating conservation flows primarily for salmonids, particularly for those in snowmelt streams, and was never validated for use in torrential tropical streams. IFIM as applied in Hawaii was not modified in anyway to reflect the Hawaiian environment. The underlying assumption in IFIM is that fish habitat can be defined by fish velocity preferences and that fish populations respond to habitat availability, i.e., increasing or decreasing with available habitat by moving to preferred velocity habitat. Conservation flows could be negotiated using IFIM, where no fish are found, under the assumption that providing preferred velocity habitat could recruit fish. These assumptions were judged to be unreasonable for Hawaiian gobid fishes, which were found to use velocity shelters, i.e., fish preferred zero velocity, and for Hawaiian streams where torrential flow regimes increased and decreased within hours, i.e., fish habitat availability fluctuated wildly within hours with changes in stream flow. Whatever factors were driving Hawaiian goby population dynamics could not be explained or accounted for using the IFIM protocol.

The gobies are adapted to highly variable, torrential stream environments and freshets. Populations are under constant stress with highly variable flows and evolved to adapt to these conditions. Flow variability will change as a result of water diversion but IFIM did not have a method for determining the significance of that change in streams that experience flows of a torrential nature. IFIM could not provide insight regarding the potential impact flow diversions would have on the stream ecology in general or, more specifically, the goby populations. As such, negotiating conservation flows using IFIM for a single set flow regime could not be detrimental for organisms adapted to highly variable torrential flow conditions.

IFIM was a bad approach to this particular problem because the underlying biological assumptions in the model were not developed for fish that were well adapted for life in torrential stream environments and that preferred velocity shelters. The underlying assumption that the population responded to available habitat, as envisioned in IFIM, was unreasonable from the observed populations in Hawaiian streams, particularly when habitat would increase and decrease in a matter of hours. Baseline population was probably restricted or related to a minimum or mean lower low flow rather than habitat as computed by IFIM. Life biology studies suggest that populations of endemic stream organisms in Hawaiian streams required both a conservation flow, as well as a maintenance of flow variability not related to simply hydraulic factors used in IFIM.

Summary

The IFIM results did not reflect Hawaiian stream ecology and could not be used to negotiate conservation flows. Even if the IFIM is modified to reflect Hawaiian stream hydrology there is still insufficient knowledge about the gobies hydrologic ecology requirements throughout their life cycle. The Honolulu District was successful in initiating jointly-funded hydraulic ecology studies in Hawaiian streams in cooperation with the ERDC, University of Dayton, US Environmental Protection Agency, Region IX, the State of Hawaii, Department of Land and Natural Resources, Aquatic Division, and the University of Hawaii. However, the hydropower permit was withdrawn prior to any regulatory decision, negating further Honolulu District participation in alternative stream assessment methodologies or cooperative hydraulic ecological studies. These studies continue under the auspices of the State of Hawaii, the University of Dayton and the US Geological Survey.

Since it was determined that IFIM was not applicable for Hawaiian streams, and no other methodologies were available for establishing conservation flows, the District was headed towards attempting to maintain flow variability by mimicking historic flows of record. After the permit application was withdrawn there was no pressing need to continue assessing conservation flow methodologies or gathering data to mimic historic flows.

For more details on this subject, please contact Michael Lee (808-438-3063) -

Editor's note: Michael Lee is an Environmental Biologist and Program Manager in the Pacific Ocean Division.

Current Events and Articles of Interest

The National Wetlands Mitigation Action Plan (MAP) was issued on December 24, 2002, along with Regulatory Guidance Letter 02-2. The MAP included a component for mitigating impacts to streams. The Corps was designated the lead agency for developing this stream mitigation guidance, and on March 1, 2003, the first phase of this effort was implemented. This first step was to poll the 38 Corps districts to identify existing stream protocols. Some of the known stream evaluation/information includes: *Stream Corridor Restoration: Principles and Practices* (Federal Interagency Stream Restoration Working Group), Stream Classification System (Rosgen 1996)[2], various hydrogeomorphic models of rivers and headwater streams, the Louisville District Stream Assessment Protocol for eastern Kentucky, and a number of Corps field office independent stream assessment approaches and operating procedures (Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee). Corps Headquarters, along with the other Federal agencies, will be working with watershed planning groups, states with designated impaired streams, state wildlife agencies, and private landowners to develop a guidance document. The guidance document will identify the issues (e.g., the need to mitigate stream loss/impacts with stream benefits as opposed to benefits for other water types), clarify considerations for mitigating impacts to streams, and provide a list of available resources and sources for obtaining information and models on assessing stream impacts and potential benefits to compensate for those stream impacts. The schedule for this effort, after the initial March 1, 2003 request for source information (due April 1, 2003), calls for consolidating the information into one document by June 1, 2003, transmitting the consolidated information to interested stakeholders for review and comments by July 1, 2003, and finalizing the document by September 15, 2003. Corps Headquarters looks forward to working closely with the field in developing a useful document for this important effort. The Corps point-of-contact for this effort is Ms. Katherine Trott (202) 761-4617.

[2] Rosgen, D. 1996 *Applied River Morphology,* Wildlife Hydrology, Pagosa Springs, Colorado.

NRC Report: *Riparian Areas: Functions and Strategies for Management*

The National Research Council (NRC) has published Riparian Areas: Functions and Strategies for Management. This report is an outgrowth of the NRC report Wetlands: Characteristics and Boundaries. The committee was chaired by Mark Brinson. The report provides a comprehensive look at riparian areas. Overarching conclusions and recommendations are identified below.

- *Restoration of riparian functions along America's waterbodies should be a national goal*
- *Protection should be the goal for riparian areas in the best ecological condition, while restoration is needed for degraded riparian areas*
- *Patience and persistence in riparian management is needed*
- *Although many riparian areas can be restored and managed to provide many of their natural functions, they are not immune to the effects of poor management in adjacent uplands.*

A review of this report will be included in an upcoming issue of the Aquatic Resources Newsletter.

Newsletter Communication

To comment on the newsletter, suggest topics, submit an article, or suggest events or articles of interest, please contact Bob Brumbaugh at:

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